Delayed Biological Effects

General Public

July 2002

Fact Sheet #14

Environmental Health Programs
Office of Radiation Protection

Washington State Department of Health

The health effects of radiation are based on studies of radiation exposure to humans, animals, and cells. Although useful, cellular and animal studies alone cannot be reliably used to predict effects in humans. The primary source of information comes from human studies involving the Japanese atomic bomb survivors, radiation accidents, occupational exposures, and medical exposures.

What is known from these studies are: 1) High doses of radiation can produce serious biological effects in humans, and the risks can be quantified. All of the observed effects of ionizing radiation in humans occur at relatively high doses (greater than 10-20 rem) and high dose rates. 2) The human data at low doses (those below 10-20 rem) and low dose rates are not adequate to quantify biological effects in humans. Whatever the risks may be, they are too small to measure with currently available methods. At the low doses of a few rem that are of interest to radiation workers and the public, the data are inconclusive, mainly because the change in cancer mortality that might occur at such low doses is less than the variations that occur for all other reasons.

Consequently, the risks associated with low dose exposures must be hypothesized. Typically, the low dose risk is estimated by some procedure of extrapolation from the known risks at high doses. There is much disagreement about such a procedure, and numerous models of the dose-risk relationship at low doses have been suggested.

National and international radiation advisory councils have conventionally adopted a model considered prudently conservative: a linear extrapolation all the way down to zero dose of the risks determined from observed effects at high doses. This model is referred to as the Linear No-Threshold model (LNT).

WHAT IS DOSE?

The amount of radiation energy absorbed in the body or parts of the body is the radiation dose. Dose to the body is measured in units called rem (roentgen equivalent man) or in millirem (1/1000th of a rem). The average dose to a member of the public from background radiation is 0.36 rem/year (360 mrem/year). However, background dose varies widely depending on where a person lives. Radiation protection guidelines limit excess dose (dose above background) to 0.1 rem/year (100 mrem/year).

We have learned many things from the studies done on the survivors of the atomic bombs. The most important are:

- For doses above 10-20 rem where effects have been observed, the more radiation dose a person receives, the greater the chance of developing cancer.

- It is the *chance* of cancer occurring, not the *kind* or *severity* of cancer, that increases as the radiation dose increases

- Most cancers do not appear until many years after the radiation dose is received (typically 10 to 40 years).

SO HOW DOES IONIZING RADIATION AFFECT US BIOLOGICALLY?

Human tissue is composed of cells. There are basically two types of cell in the body (a) 'germ cells' used in reproduction of the species and (b) 'somatic' or 'body cells' used to form the various organs. Any problems from radiation damage to a somatic cell will affect only the irradiated individual. Damage to a germ cell (mutation), however, can also be passed on to future generations - genetic damage. For the entire dose of radiation we accumulate over a lifetime from natural background radiation, the hypothesized risk of developing cancer is estimated by the LNT model to be about one in one hundred. Based on this hypothesized risk estimate, five percent of all fatal cancers in the U.S. are caused by background radiation. The additional contribution from all man-made sources of radiation is much smaller.

For high doses, the risk that exposure to ionizing radiation will cause cancer is observed to be proportional to the dose received. At the low doses that most of us might ever expect to encounter, the risk is hypothesized to be proportional to dose, and is very low indeed. However, there is no good reason to believe that there is any threshold level of dose below which risk is reduced to zero.

As with any studies using statistics, the numbers are not hard and fast. The numbers in the examples below are good approximations, and can vary several percentages plus or minus.

Using the LNT model, it is presently estimated that if one million people each receive 100 rem of whole body radiation, forty-five will develop a fatal cancer. Approximately thirteen serious hereditary defects will also be caused over all future generations descended from the one million exposed persons. To put these figures in perspective however it should be noted that in any population of one million there will be about 2,000 deaths a year from cancer induced by all causes (i.e., not only by radiation) and about 200 births per year with hereditary defects attributed to mutations from all causes.

Sources

Enfo – Environmental Information Service Website
U.S. Environment Protection Agency, http://www.epa.gov/